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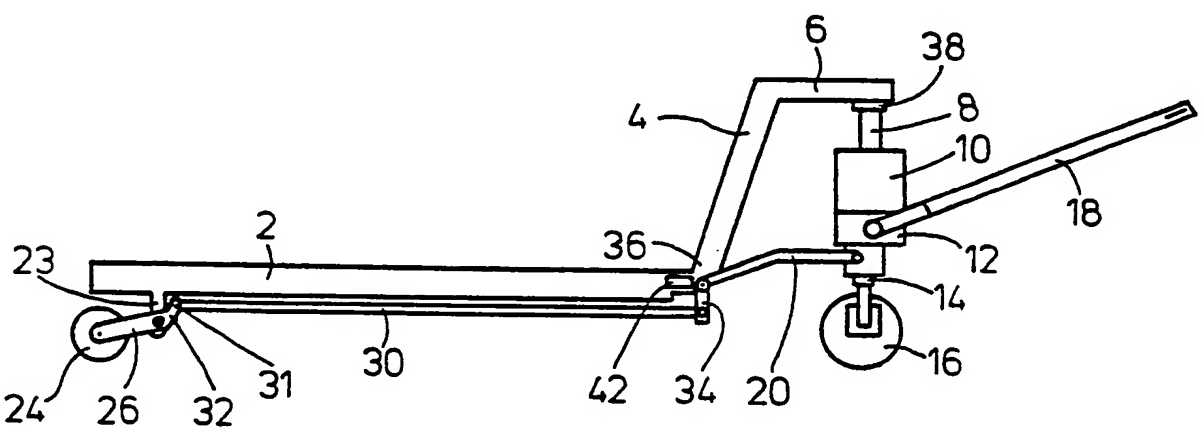
(54) Title: A LIFTING DEVICE SUCH AS A LIFTING CART WITH MEANS FOR MEASURING THE WEIGHT OF THE LIFTED LOAD



(57) Abstract

In many lifting devices, e.g. fork lifting carts, lift systems are used, in which there is a pronounced non-linear transfer function between the lifting height and the applied lifting force. It can be desirable to determine the weight of the lifted load directly on the device, using but a single pressure sensor (33). It is known that such a measuring can be carried out at a predetermined lifting height, where there is a known value of the said transfer function, but the measurement may be highly inaccurate if the load is under acceleration through the measuring level. The invention provides for means (42) for detecting the lifting height and an associated calculator (44), which is currently informed of the lifting height and the lifting force, and which is programmed with the non-linear transfer function. Thereby the weight measurement can be correct at any height, but the lifting force may vary due to the inertia of the load, when lifted with non-constant velocity, and on that background the calculator is adapted such that operative weighing results are accepted only when they are at rest, e.g. during the periods of rest by a manual pumping up of the forks of a fork lift cart.

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A lifting device such as a lifting cart with means for measuring the weight of the lifted load.

The present invention relates to a lifting device of the type specified in the precharacterizing clause of claim 1, i.e. a fork lift cart, for example. Such carts have floor supported carrier means, e.g. forks, that are supported by means of driving and carrying wheels mounted on pivot levers, which can be operated to pivot between lying positions, in which the carrier means assume a lowered position, and oblique positions, in which they hold the carrier means pressed upwardly from the floor. Lifting carts of this type are used in large numbers, often for manual operation, and it has been a desire to also make available a modified type provided with a system, by means of which it is possible to read the weight of the single loads on the carts. There is of course no principal problem in this, yet there is a practical problem, viz. that the weighing system should be both cheap and reliable, even though a high accuracy will seldom be required. It is known that the more accurate weighing results are achieved by placing between the carrier means and an overlying load carrier plate a number of weighing cells connected with an electronic calculator for showing the weighing result, but the carrier means may be rather unevenly loaded, such that for a reasonably accurate weighing result it would be required to make use of several weighing cells, e.g. three at either side, and as well known good weighing cells are quite expensive, just as it is a complication to arrange for the said upper carrier plate or plates.

Another and cheaper solution has already been developed, based on a measurement of the lifting force transferred to the carrier means from the actuator means, whereby a single measurement will be sufficient.

It has been required to overcome the weighing technical problem that this force is not uniquely determined, because it shall have to be high at the initial lifting of the load, since in this phase there is a large momentum acting on the said pivot levers, while the momentum decreases the more the levers are swung up from their lying positions. This problem has been solved by arranging for an automatic readout from a force sensor in response to the liftable system passing through a well defined height level over a cart portion that is supported on the floor in a constant height; the transfer relation between the actuating force and the lifting force will then be known in just that level, corresponding to an accurately predetermined angular position af the said pivot levers and including the dead weight of the raisable system of the cart.

In principle this solution is good, but it can give rise to very distorted weighing results. It is quite common that the lifting means are actuated by successive working strokes, by each of which, due to the inertia of the lift system, a temporary increase of the transferred force will occur, and the result of the weighing will then be dependent of whether the automatic actuation of the force gauge takes place in a phase in which the force, for the said reason, is relatively high or low, whereby the result will be unsafe.

Correspondingly there are many other lifting devices, by which weighings could be relevant, e.g. front loaders and tailboard lifts, which are raised by a non-linear force transmission and can be started and stopped in any height positions.

It is the purpose of the invention to provide a lifting device, by which the weight of the load can be determined with a good accuracy and yet by simple means.

According to the invention this is achieved by the lifting device being designed as stated in the charac-

terizing clause of claim 1.

The invention still makes use of the very simple weighing principle that the weight is determined based on a detection of the occurring pressure or pull between the power exerting lifting means and the entire load being lifted, such that it is sufficient to use a single weighing cell or pressure transducer, but it has been recognized that the said inaccuracy can be counteracted by avoiding an operative weighing in any specific height position of the raisable system, but rather by weighing continuously over an enlarged range of movement, when only care is taken to keep the calculator informed of the height of the load, e.g. expressed by the angular position of the said pivot levers. The angular position can be detected by simple means, e.g. a potentiometer mounted in the pivot axis, and the calculator will then translate the weighing signal into a correct weight measurement, with the required correction for the angular lever position. Still pulsations may occur in the measured transfer force, dependent of an intermittent operation of the lifting means, but the calculator is adapted such that it will detect only the minima of the transfer force and calculate the weight correspondingly. This can be done just because it is also possible to correct for the changes owing to the angular movement of the pivot levers and the associated change in the transfer ratio between the transfer force and the actual weight of the raisable system.

It is well known that with manually operated lifting carts is is required to 'pump' at least some times with the actuator system in order to bring the load to a suitable height of transportation, and for the calculator it will sufficient to detect just a few force minima in order to carry out a reasonably accurate determination of the weight. The system according to the invention will be entirely independent of how much

excess power is used in the actuation strokes, and also of the strokes being long or short.

In the following the invention is explained in more detail with reference to the drawing, in which:

Fig. 1 is a schematic lateral view of a lifting cart according to the invention, while

Fig. 2 is a graphic representation of certain forces in action by the actuation of the lifting cart.

The lifting cart shown is of a conventional design, comprising a pair of lift forks 2, the front ends of which are connected with an upright tower portion 4 having at its top a horizontal portion 6, which is supported on a piston rod 8 belonging to a hydraulic cylinder 10. This cylinder is mounted standing on a unit 12, which, itself, is supported by a lower, turnable wheel holder 14 for a foremost carrying and steering wheel 16. To the unit 12 is connected a forwardly projecting steering and pumping rod 18, with which the cart can be drawn and pushed as well as steered, as the wheel holder 14 and therewith the wheel 6 can be turned by means of the rod; the wheel 6 may be a twin wheel. Between the unit 12 and the lower end of the tower 4 is provided a pivot lever 20 which, together with the upper tower portion 6, stabilizes the vertical position of the front structure 8,10,12,14.

At their outer ends the forks 2 are supported by wheels 24 mounted at the outer ends of respective pivot levers 26, which are hinged to brackets 28 at the underside of the forks. A downwardly directed pivoting of these levers, which are initially only slightly downwardly inclined, will result in a raising of the outer ends of the forks, and for controlling the pivot movements there is provided a control rod 30 extending between a pivot point 31 on an upper prolongation 32 of the pivot lever and the outer end of a depending angular arm 34 on the foremost pivot lever 20, this lever being

pivotal in a lower bearing 36 of the tower 4.

The unit 12 is a hydraulic station having a pump, which is actuated by the steering and pumping rod 18 being swung downwardly to thereby force hydraulic liquid into the cylinder 10, such that the tower 4 is raised somewhat by each pumping stroke. The immediate result is that the tower and the associated foremost or innermost ends of the forks 2 are raised, but as a result the the lever 20 will be pivoted in the bearing 36 such that the arm portion 34 is swung to the left, whereby the rod 30 is pushed towards the left, thus forcing the pivot lever 26 to swing downwardly. This implies a raising of the outer ends of the forks 2, and the system is laid out such that the same degree of raising will occur at both the outer and the inner ends of the forks, i.e. the forks and the load carried thereon will be raised parallel to the initial position.

Described so far the lifting cart is of a fully conventional design. For enabling the lifted load to be weighed there is introduced into the raising system a force transducer or weighing cell, shown by way of example as a weighing cell 38 inserted between the upper end of the piston rod 8 and the overlying part 6 of the tower 4. This cell is affected by the joined weight of the load and the raisable system 2,4,6, and when the weight of the latter is known it is possible to determine the weight of the load with the use of a simple calculator. As mentioned, however, the weighing result may be inaccurate based on the fact that ongoing pumping strokes with the rod 18 give rise to dynamic forces, which, due to the inertia of the raisable system, will be stronger than the influence caused solely by the combined weight of the raisable system and the load carried thereon. Moreover, as the pivot levers 20 and 26 are swung downwardly the pressure detected by the weighing cell 40 will vary in a non-linear manner for an

increasing lifting height, because angular movements occur in the force transfer system. Initially by the raising the required force is relatively high, while the needed force will decrease as the pivot lever 26 pivots towards a vertical position.

In accordance with the invention this problem is overcome by mounting at a suitable place in the raising system a sensor for detecting the said angular movements of the system parts, such that the calculator unit can be currently informed of the height position of the system. This can be detected in many different manners, but it is shown as an example that in connection with the bearing 36 for the angular arm 22,34 there can be provided a detector 42 for the angular position of this arm, e.g. in the form of a potentiometer. All according to the geometry of the raising rod system it can be predetermined, which transfer function will occur between the load on the raisable system and the force required for raising this load during the raising interval, and this function can be read into the calculator as a control function.

In Fig. 2 it is shown as an example, which is not necessarily representative for the geometrical system of Fig. 1, that by the initial lifting of the load a rather strong raising force will be needed, whereafter the force will decrease along the depicted smooth curve 'a' as the system is raised. For illustrating the prior art it is marked that it is possible to detect the raising force at a certain raising level H, in which the said transfer ratio is known, whereafter - if the system is at rest - the result can be used for determining the load on the forks 2. The corresponding raising force on the curve 'a' is shown by the point P.

It is here a problem, however, that the raisable system may perhaps not be at rest when this measurement is made, because the system is being pumped upwardly by

means of the pumping rod 18. Because of the inertia of the system the pumping force during the working strokes will increase to a value above the required raising force, this in Fig. 2 being illustrated by a wavy curve b, which is located above the curve 'a', though coinciding therewith during the periods of time in which the pumping rod is pivoted upwardly preparatory to the following pumping stroke, as the system will be at rest during such periods. The raising height H may well be passed during a phase in which the raising force is increased, due to the said inertia, and the real, measured raising force will then not be the point P, but a point P' on the curve b, whereby the weighing result may be significantly wrong.

According to the invention the calculating unit is designed so as to detect the minima, M, occurring on the curve b, and moreover the unit is preprogrammed with the said transfer function, here represented by a curve c, the values of which should be added to the detected measuring results M, whereby for each measurement a true value of the weight of the load on the raisable system can be provided, e.g. as shown by the dotted line d. In a time based diagram the points M will appear as horizontal line segments.

Already a single measurement can be sufficient, but of course the accuracy will be improved if more measurements are made during the raising sequence, this normally comprising several pumping strokes with associated pauses therebetween, in which pauses the pressure can be measured with the system in a condition of rest.

Minor variations in the transfer function may occur all according to the load being placed at the front end or the rear end of the forks. The calculator, however, may be adapted such that based on a few measurements it can detect whether the shape of the curve corresponds to a central or a more or less displaced position of the

load, and hereby the calculator can carry out the required correction of the weighing result.

In the foregoing the invention has been explained in connection with a manually operated lifting cart, but it is to be understood that the principle of the invention is not correspondingly restricted, as also in other connections similar problems can exist, such that the principle of the invention can be utilized in an advantageous manner.

C L A I M S :

1. A lifting device such as a fork lifting cart having a load carrier part and an actuator part, which is operable to apply to the carrier part through a transfer system a lifting force for lifting the carrier part with a non-linear transfer function, and having means for measuring the weight of the lifted load based on a detection of the force required for raising or carrying the load, characterized in that the lifting device is provided with means for detecting the lifting height and reading the same into an associated calculator unit, which is preprogrammed with the transfer function between the lifting force and the weight of the load at the different load lifting levels, and that the calculator unit is adapted so as to operatively detect only such relative minimum values of the lifting force which occur during the lifting of the load when the load is at rest or is non-accelerated during the lifting thereof.

2. A lifting device according to claim 1, by which the load is lifted by several manually effected pumping strokes, characterized in that the calculator unit is adapted to effect the weight detection during such periods of time, in which the load is at rest between the consecutive pumping strokes.

3. A lifting device according to claim 1, characterized in that the means for detecting the lifting height are constituted by means such as a rotary potentiometer for determining the angular position of a pivot lever of the transfer system.

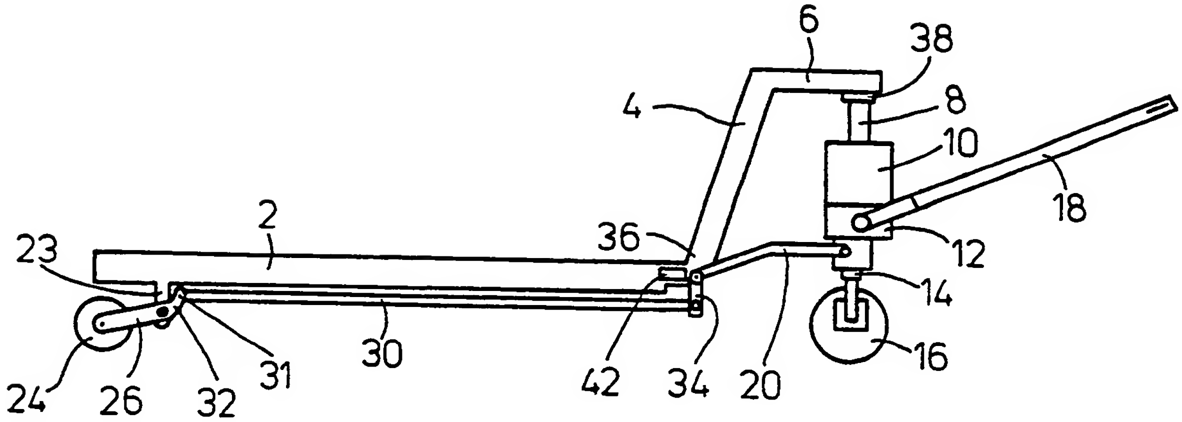

FIG. 1.

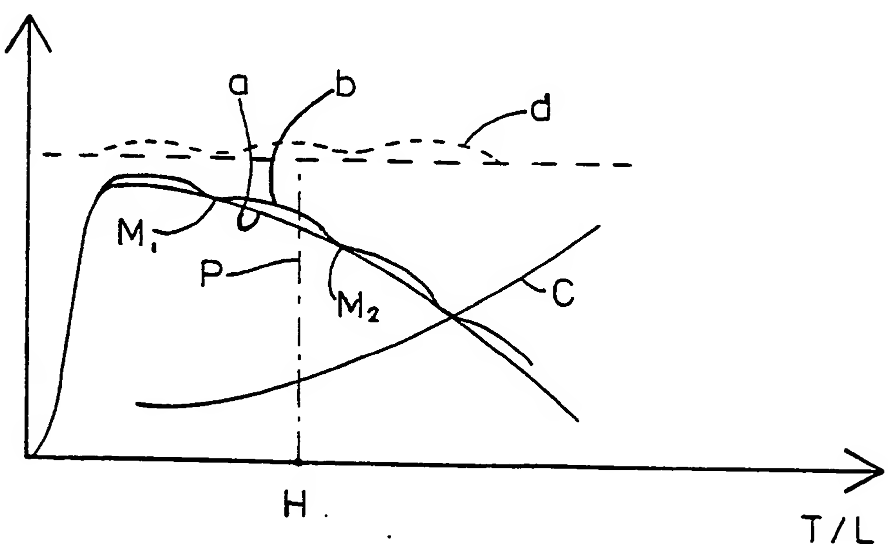

FIG. 2.

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 90/00333

I. CLASSIF.CATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]
According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: B 66 F 17/00, G 01 G 19/08

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	B 66 F; G 01 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	WO, A1, 8202024 (ERGOTEST AB) 24 June 1982, see page 4, line 15 - line 31; figures 3-4 -- --------	1-3

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25th March 1991	1991 -03- 26
International Searching Authority	Signature of Authorized Officer
SWEDISH PATENT OFFICE	Catarina Forrén Catarina Forrén

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/DK 90/00333

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 91-02-28
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A1- 8202024	82-06-24	EP-A-	0066578	82-12-15